

Early Signs of New Physics at the LHC

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Based on:

- H. D. (BNL), G. Perez (SBU), and A. Soni (BNL)

Phys.Lett.B665:67-71,2008, arXiv:0802.0203 [hep-ph]

- H. D., S. Gopalakrishna (BNL), and A. Soni

Phys.Lett.B686:239-243,2010, arXiv:0908.1131 [hep-ph]

- H. D., T. McElmurry (BNL), and A. Soni

Work in progress.

DOE HEP Review

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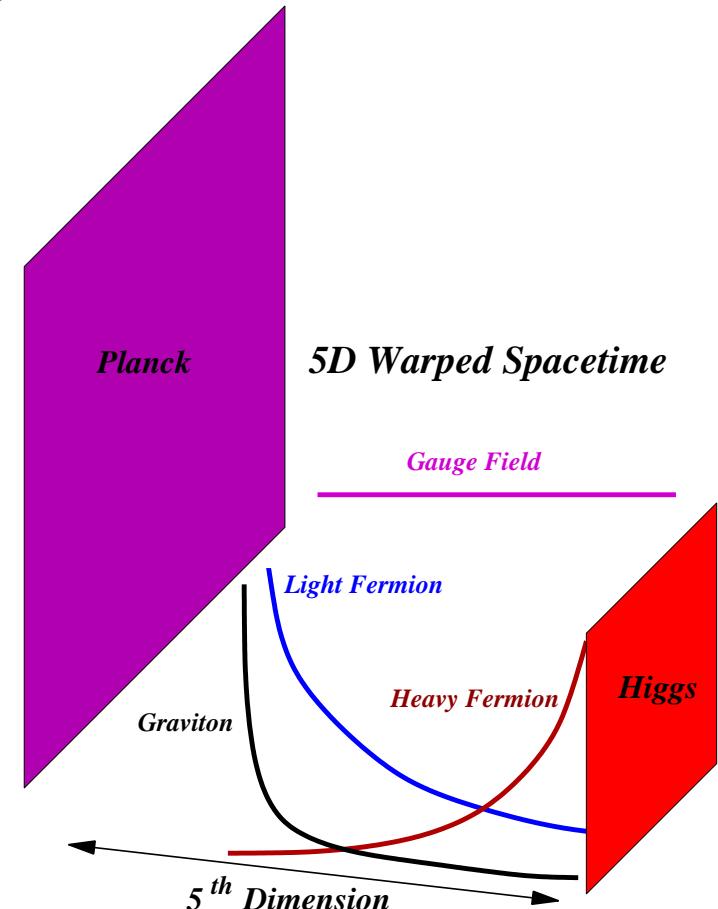
Introduction:

- The SM hierarchy problem: $\langle H \rangle / \bar{M}_P \sim 10^{-16}$ ($\bar{M}_P \sim 10^{18}$ GeV).
- Warped 5D **Randall-Sundrum (RS)** model: $k, \pi r_c$. Randall, Sundrum, 1999
 - $\langle H \rangle_5 \sim M_5 \sim \bar{M}_P$ and $e^{-kr_c\pi} M_5 \sim \text{TeV}$ for $kr_c\pi \approx 35$ (exponential redshift).
 - SM in 5D RS: geometric explanation of **flavor**.
 - TeV-scale Kaluza-Klein (KK) resonances at LHC.
 - $\mathcal{O}(100)$ GeV scale radion (r_c fluctuations).

- **Little RS (LRS)** models: H.D., Perez, Soni, 2008

Model of flavor: $\text{TeV} \ll M_5 \ll \bar{M}_P$.

- $1 \ll kr_c\pi \ll 35$ (truncated volume).
- Some constraints are relaxed.
- Still explain $\langle H \rangle / M_5 \ll 1$.
- $q\bar{q} \rightarrow Z' \rightarrow \ell^+ \ell^-$; $\ell = e, \mu$ *clean, early data*.
- Little KK gluons: more challenging $t\bar{t}$.
- Little radion: enhanced $gg \rightarrow \phi \rightarrow \gamma\gamma$.
(Could be interesting for $\sqrt{s} = 7$ TeV.)



Enhanced Signals

- LRS truncation factor: $y \equiv (kr_c\pi|_{RS})/(kr_c\pi|_{LRS})$ ($y > 1$)
- $g_{KK}|_{UV} \sim g_4/\sqrt{kr_c\pi}$ (q, e, \dots) ; $g_{KK}|_{IR} \sim g_4\sqrt{kr_c\pi}$ (H, t, \dots)

Signal \mathcal{S} : $\sigma(q\bar{q} \rightarrow Z' \rightarrow \ell^+\ell^-) \propto \overbrace{\Gamma(Z' \rightarrow q\bar{q})}^{\sim y} \overbrace{\text{BR}(Z' \rightarrow \ell^+\ell^-)}^{\sim y^2}$

$\therefore \boxed{\mathcal{S} \sim y^3}$ and $\boxed{\mathcal{S}/\mathcal{B} \sim y^4}$! Background: $\mathcal{B} \sim 1/y$ (over width)

- Enhanced Little KK gluon production (requires $t\bar{t}$ reconstruction).
 - Discussions with local ATLAS members (T. Gadfort, H. Ma, M. Pleier).
- Tree-level radion coupling to gg and $\gamma\gamma \propto 1/(kr_c\pi)$.
 - Prospects for early $gg \rightarrow \phi \rightarrow \gamma\gamma$ signal, work in progress.
- Sensitivity to the UV-brane scale.

$$y \approx 1 \Rightarrow M_5 \sim \bar{M}_P ; \quad y \gg 1 \Rightarrow M_5 \ll \bar{M}_P.$$

Assume a TeV-scale KK mode is discovered.



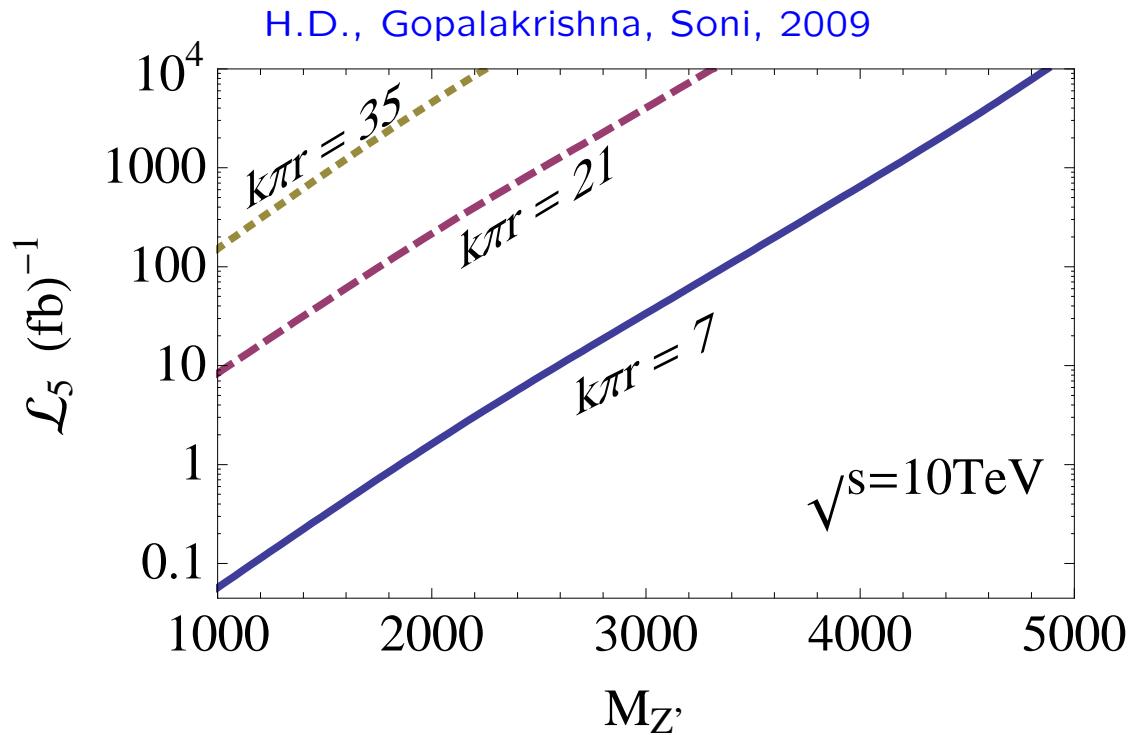
Question:

Is the Planck-weak hierarchy resolved?

Clean signals sensitive to truncation.

Experimental handle on $kr_c\pi$ (M_5) in typical models.

LHC Z' reach in the dilepton channel ($\sqrt{s} = 10$ TeV)



- \mathcal{L}_5 : $\int L dt$ for 5σ signal (≥ 3 events) in $pp \rightarrow \ell^+\ell^-$ ($\ell = e$ or μ).
- Little KK gluons: may need $\lesssim 1\text{fb}^{-1}$ for $m = 2$ TeV at $\sqrt{s} = 10$ TeV. Worth considering $\sqrt{s} = 7$ TeV, discussions with ATLAS.
- Little radions may be good candidates for the $\sqrt{s} = 7$ TeV run:
sub-TeV masses, enhanced clean di-photon signals.

Concluding Remarks

- LRS models of flavor: stable hierarchy up to the UV scale $M_5 \gg \text{TeV}$, some unwanted effects suppressed by truncation.
- Clean radion and KK signals sensitive to $kr_c\pi$ (M_5).

TeV data → Microscopic information on underlying theory

- For $M_5 \sim 10^4$ TeV (safe flavor scale), 2-TeV Little Z' at $\sqrt{s} = 10$ TeV with 1fb^{-1} , in clean dilepton channel (early physics).
- Enhanced production of Little KK gluons could make them accessible at early stages, depending on $t\bar{t}$ reconstruction (discussions with ATLAS).
- Diphoton signals of Little radions with $m_\phi \sim 100$ GeV may be of interest to the 7-TeV run (work in progress).